Small Business Innovation Research/Small Business Tech Transfer

A Scalable Gas-Particle Flow Simulation Tool for Lander Plume-Surface Interaction and Debris Prediction, Phase I

Completed Technology Project (2018 - 2019)

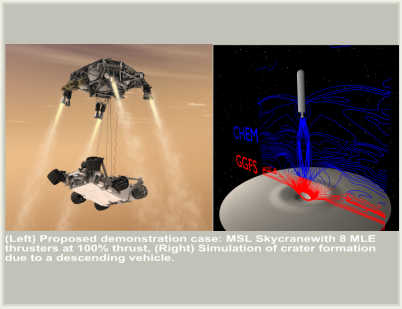
Project Introduction

Spacecraft propulsive landings on unprepared regolith present in extra-terrestrial environments pose a high risk for space exploration missions. Plume/regolith interaction results in (1) the liberation of dust and debris particles that may collide with the landing vehicle and (2) craters whose shape itself can influence vehicle dynamics. To investigate such gas-granular interactions for large-scale problems using standard Lagrangian approach, particles on the order of billions would need to be modelled to account for large landing areas, making the approach impractical. An effective alternative is to use an Eulerian-Eulerian approach where the granular mixture is represented using a two-fluid model and the granular material physics are considered using constituent relations. This effort aims to provide a state-of-the-art Eulerian-Eulerian approach with novel granular material models in the highly scalable computational framework Loci used by NASA engineers. At the end of Phase I, a massively parallel Loci-based version of a gas-granular flow solver featuring compressible flow, single gas species, and novel granular material models for spherical and irregular (single-component) particle mixture will be developed and demonstrated, with a TRL starting at 2 and ending at 4. Phase II effort will add higher model fidelity to the gas phase with a multi-component approach, an extension of the granular models for poly-disperse mixtures, overset-mesh with six degrees-of-freedom for lander vehicle motion, and compatibility to other Loci-based tools and modules such as CHEM.

Anticipated Benefits

Potential NASA commercial applications include the NASA led lunar and Mars lander development projects. Human class Mars lander plume-surface analysis is provided to propulsive Entry, Descent, Landing and Ascent (EDL&A) systems integration teams under the Evolvable Mars Campaign (EMC). Lunar lander developments include the NASA led Lunar Pallet Lander and industry lunar landers by Masten, Astrobotic, and Blue Origin which benefit from NASA technical support through the CATALYST program.

Potential non-NASA applications include a wide range of sand and dust related military and civilian applications such as rotorcraft sand/dust brownout and engine dust ingestion. In addition, multiphase flows occur in many applications in chemical, petro-chemical and fossil-energy conversion industries where accurate modeling of particle shape play a huge role in the flow behavior of real particulate systems.



(Left) Proposed demonstration case: MSL Skycranewith 8 MLE thrusters at 100% thrust, (Right) Simulation of crater formation due to a descending vehicle.

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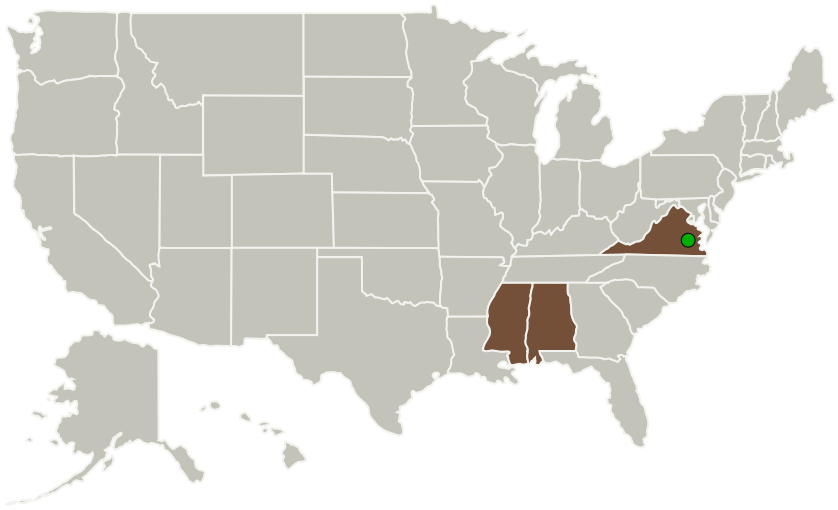
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
CFD Research Corporation	Lead Organization	Industry	Huntsville, Alabama
Langley Research Center(LaRC)	Supporting Organization	NASA Center	Hampton, Virginia

Primary U.S. Work Locations	
Alabama	Mississippi
Virginia	

Project Transitions

August 2018: Project Start

August 2019: Closed out

Closeout Documentation:

- Final Summary Chart*(https://techport.nasa.gov/file/141201)*

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

CFD Research Corporation

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

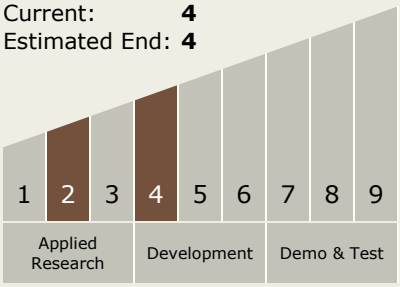
Carlos Torrez

Principal Investigator:

Manuel Gale

Technology Maturity (TRL)

Start: **2**
Current: **4**
Estimated End: **4**



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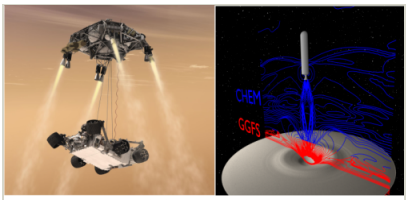
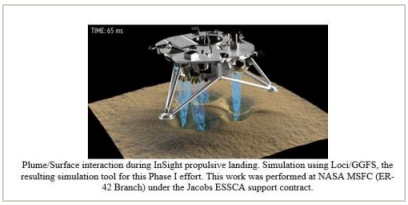
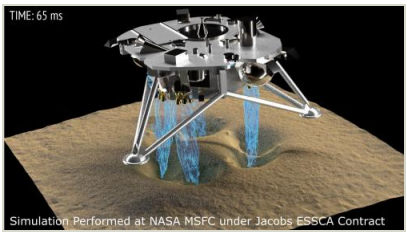
Images



Briefing Chart Image
A Scalable Gas-Particle Flow Simulation Tool for Lander Plume-Surface Interaction and Debris Prediction, Phase I
(https://techport.nasa.gov/image/133631)



Final Summary Chart Image
A Scalable Gas-Particle Flow Simulation Tool for Lander Plume-Surface Interaction and Debris Prediction, Phase I
(https://techport.nasa.gov/image/127049)



Final Summary Chart Image
A Scalable Gas-Particle Flow Simulation Tool for Lander Plume-Surface Interaction and Debris Prediction, Phase I
(https://techport.nasa.gov/image/126940)

Technology Areas

Primary:

- TX09 Entry, Descent, and Landing
  - TX09.4 Vehicle Systems
    - TX09.4.5 Modeling and Simulation for EDL

Target Destinations

The Moon, Mars, Others Inside the Solar System